AUTOMATIC BOOK BINDING MACHINE

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ABSTRACT

This thesis describe about the automatic book binding machine. This machine is using the hydraulic system, where the punching process and binding process use hydraulic cylinder. This automatic book binding machine is use a 'puncher' concept, and then compiles all the paper to bind. It can operate in two conditions which is manual and automatic. In manual system, it just use direct wiring, while in auto system, it will be controlled by PLC. The programming in PLC are using ladder diagram. In hydraulic system, the motor that will be used is 3 phase motor where is 3hp. The operation start with, the book will be placed in one basement book and the cylinder 1 will retract and punching process will happened. Then the motor will move the basement book to binding stage and the process will continue. To make the operation become smoothly, it used inductive sensor to detect every station to stop. This machine is using less human energy in binding book. The consumer only just push the button to make this machine functioning

CHAPTER 1

INTRODUCTION

1.1 Overview of a Book Binding Machine

In the past few decades, the current market has not evolved in producing book binding machine. There are many types of book binding machine available to bind books such as comb binding machine, wire binding machine, stapler binding machine and many more. All those types of book binding machines are designed to bind books manually. It uses human energy to bind the book. Human has limited capabilities and this may lead to lack consumes of energy, thus a good quality of binding is unable to produce; especially for thicker books.

The automatic book binding machine is designed to fulfill customer needs and it can also minimize the usage of human energy in binding the book. In terms of automatic machine, it uses PLC (Programmable Logic Controller). On the other hand, this machine also uses the hydraulic system, to make sure it could bind very thick book. This hydraulic system has high energy to punch and bind the book. However this automatic book binding machine can only bind books with the size of A4 paper.

1.2 Project Objectives

The objectives of this project are to design an automatic book binding machine using PLC as a controller and the machine could bind a book in a range of 10mm to 15mm thickness.

1.3 Project Scope

This project is to design and construct the machine that can bind a book which is in A4 size in the range of 10mm to 15 mm. It can minimize human energy consumption in order to bind thick books.

In order to achieve the objectives, this project must use some elements such as inductive sensor to detect the system operation and give the information to proceed from one stage to another stage. While PLC (Programmable Logic Controller) conducts as a controller to control the movement of all the operation by itself. The hydraulic cylinder is used as an operation to punch and bind the book. Three phase induction motor 25W is used to move the book from one stage to another stage.

1.4 Thesis Outline

Chapter 1 contains explanation on the introduction of the project which consists of the overview of the problem statement, objectives, and scope of the automatic book binding machine project.

Chapter 2 is more focused on literature review which is the research and studies of this project.

Chapter 3 views the methods that are used in completing the project from the beginning to the end. This includes project's flow, analysis, and its implementation.

Chapter 4 discusses on the results obtained and the limitation of the project. All discussions are based on the results and performances of the overall book binding machine.

Chapter 5 concludes the overall of the project and which includes the problem and recommendation for this book binding machine in future development and modification.

CHAPTER 2

LITERATURE REVIEW

2.1 Programmable Logic Controllers (PLC)

A *programmable logic controller (PLC)* is a specialized computer used to control machines and processes. It uses a programmable memory to store instructions and execute specific functions that include on/off control, timing, counting, sequencing, arithmetic, and data handling.

Initially the PLC was used to replace relay logic, but its ever-increasing range of functions means that it is found in many and more complex applications. Because the structure of a PLC is based on the same principles as those employed in computer architecture, it is capable not only of performing relay switching tasks but also of performing other applications such as counting, calculating, comparing, and the processing of analog signals.

Programmable controllers offer several advantages such as:

i) **Increased reliability** – Once a program has been written and tested, it can be easily downloaded to other PLCs. Since all the logic is contained in the PLC's memory, there is no chance of making a logic wiring error. PLC's also offer the reliability associated with solid-state components.

ii) **More Flexibility** – It is easier to create and change a program in a PLC than to wire and rewired a circuit. Originally equipment manufacturers can provide system updates by simply sending out a new program.

iii) **Lower Cost** – PLC were originally designed to replace relay control logic, and the cost savings have been so significant that relay control is becoming obsolete except for power application.

iv) **Communications Capability** – A PLC can communicate with other controllers or computer equipment to perform such functions as supervisory control, data gathering, monitoring devices and process parameters, and download and upload of programs.

v) **Faster Response Time** – PLCs are designed for high-speed and real-time applications. The programmable controller operates in real time, which means that an event taking place in the field will result in the execution of an operation or output.

vi) **Easier to troubleshoot**- PLCs have resident diagnostics and override functions that allow users to easily trace and correct software and hardware problems. [1] (Frank D. Petruzella, 2005)

Many types of PLC are available such as Omron, Mitsubishi, Siemen, Nais and many more. In this project, I am using Nais PLC which has 8 inputs and 6 outputs. This PLC is suitable to control the movement of the hydraulic cylinder.

2.2 Hydraulic System

In the hydraulic system we must consider many types of components such as hydraulic motor, hydraulic cylinder, hydraulic fluids, valves, accumulators and hydraulic pumps.

Hydraulic motors are used for converting hydraulic energy into mechanical energy. Hydraulic motor may be categorized into high speed motors (n = 500 to 10 000 rpm) and slow motors (n = 0 to 1 000rpm). While the power produced by a hydraulic motor is dependent on the flow and pressure drop at the motor. [2](Rudhard Freitag, 1991)

Hydraulic cylinder is the link between the hydraulic circuit and the working machine. Hydraulic cylinder is different to the hydraulic motor which carries out the rotary movement, while hydraulic motor carries out translational (linear) movements, trough which forces are transferred. This hydraulic cylinder can be categorized into two groups which are:

i) Single acting cylinders

Single acting cylinders can only exert force in one direction. The piston can only be returned by a spring, trough the weight of the piston itself or by the action of an external force. Basically single acting cylinders have one effective area.

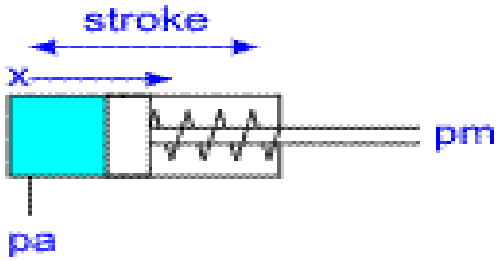

Figure 2.2.1: Single acting cylinder

ii) Double acting cylinders

Double acting cylinders have two opposing effective areas which are of the same or different sizes. They are fitted with 2 pipes ports which are isolated from each other. By feeding fluid via ports "A" and "B", the piston may transfer pulling and pushing forces in both stroke direction. [2](Paul Schwab,1991)

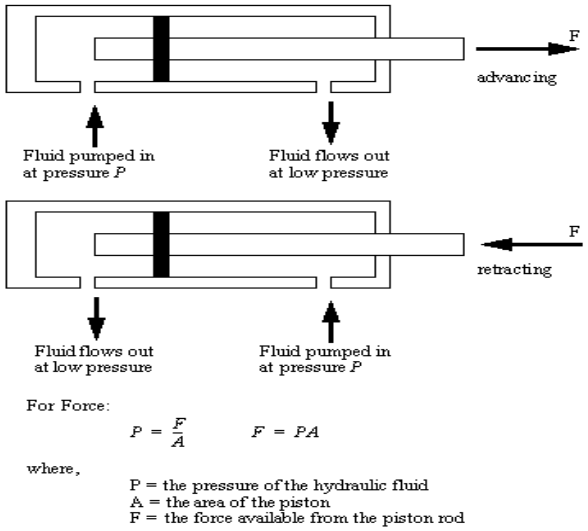

Figure 2.2.2: Double acting cylinder

Hydraulic fluid is a main function in hydraulic system is to transfer forces and movement. Further task and characteristics are required of hydraulic fluid, due to the diverse range of application and installation of hydraulic drives. The most important

when selecting a fluid is viscosity. It is not a measure of the quality of a fluid, but a stead provides information on the behavior of a fluid at the particular reference temperature. [2](Eberhard Sumpf,1991)

There are many types of valve in hydraulic system. One of them is directional valve where the most function is used. This directional valve is used to control the start, stop, and direction of flow a fluid. There are three types of directional valve, which vary in how they are constructed:

i) Directional spool valves
ii) Directional poppet valves
iii) Rotary directional valves

[2](Dr. Harald Geis, Johann Oppolzer,1991)

The main task of an accumulator is to take a specific amount of fluid under pressure from the hydraulic system and store it until it is required within the system. As fluid is under pressure, accumulators are treated as pressure vessels and must be designed taking into account the max. operating pressure. In order to store energy in accumulators, the fluid in an accumulator is weight or spring loaded or pressurized by gas.[2](Martin Reik, 1991)

Hydraulic pumps should convert mechanical energy into hydraulic energy. When choosing a pump, many points must be taken into account such as operating medium, required range of pressured, expected range of speeds, minimum and maximum operating temperature, maximum and minimum viscosities, installation, types of drives, expected life-time, maximum level of noise, ease of servicing, and maximum cost. [2](Rudhard Freitag,1991)

All these types of components are very important to consider when we want to achieve good result in this project. This is because the movement of the book and the punching and binding process were using hydraulic system.

2.3 Inductive sensor

Inductive sensor is an electronic proximity sensor, which detects metallic object without touching them. These inductive proximity detectors operate on the principle that the inductance of a coil is considerably changed in the presence of a metal core. The presence of metal closed to the coil will thus cause a bridge output off–balance condition or a change in the tuned frequency that can be sensed. The change is normally used to operate a switching circuit by way of a transistor or a Triac, so that the output is suitable for controlling a load. The predominant switch action is normally open (NO) that is no part of the switch need to touch the object being sensed.

This inductive proximity sensor only detect metallic object, and with a sensitivity that depends on the types of metal used. The sensitivity is quoted in terms of average sensing distance for an object of mild steel and, depending on the type of detector; this distance is of the order of 0.8-2mm for mild steel. Other metals lower the sensitivity, to 70% for stainless steel, 40% for brass, 35% for solid aluminum, and 30% for copper. Most inductive proximity sensors are DC operated, with the choice of current source or current sink action. A current-source type will pass current into a load; a current-sink type will accept (to ground) current from a load. Current ratings are in the 100-200mA region at DC voltage levels of 5-30V. [3](Ian R.Sinclair, 2001)

This is a good choice because all mechanical parts of the book binding machine are metal-based.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In order to make this project runs smoothly, this methodology is the one of important element to take the action. Methodology is a guide to make sure that the project goes according to the flows. It is a framework for a project.

The overall of the project can be overviewed by supervisor only by referring to the methodology. The progress of the project can be examined from time to time. The elements of the methodology of this project can be referred to the flow chart below.

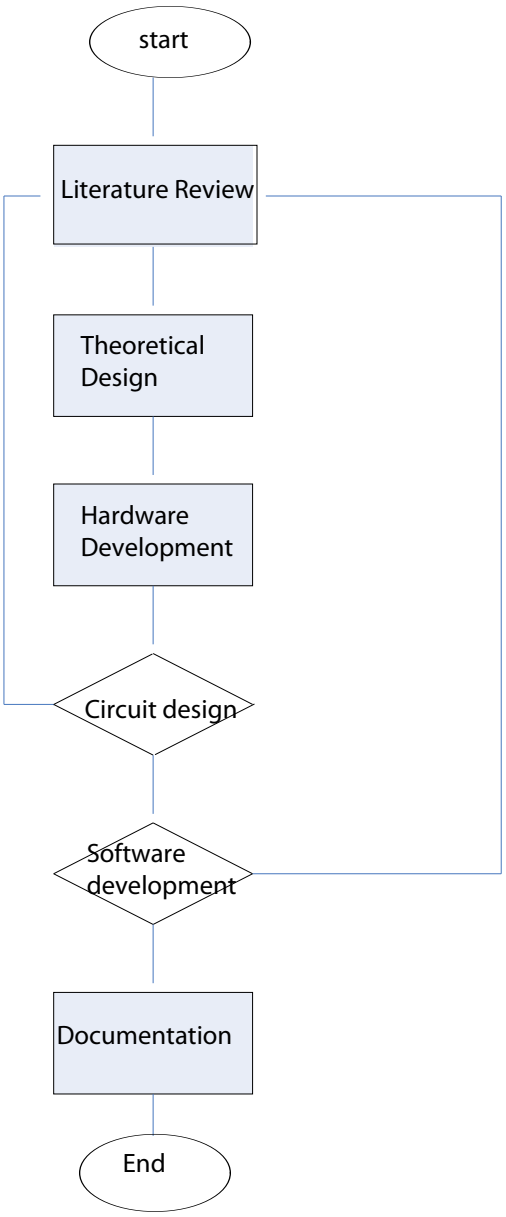

Figure 3.1: Flowchart of Methodology

In order to achieve the objective of this project, the project begins with choosing the title and discusses the problem statement of the project with supervisor. After the problem statement is understood, the objectives and scope of the project come out.

3.1.1 Literature Review

Before start the project, the second process is conducted that is; doing the research about this project and get information as much as can to learn about the previous method of the project and the components that is used in this project. The research is very important to make us clear about the project scope and it is the first layer to get the idea to design and develop the project. In this literature review, all the research comes from book, the Internet, journals and discussions with the experienced person. Those entire books are from the UMP library and borrow from someone who is very familiar with the hydraulic system.

3.1.2 Theoretical Design

After all the information is collected, then the theoretical design is developed. In the theoretical design, it considers the material that need to be used in the project that could hold the hydraulic system. Also, in this section I begin constructing the design for the size of the machine and shape of the machine.

3.1.3 Hardware Development

Then, the project continues with the hardware development which is after the theoretical design is made. This hardware development is based on the design that is made before. In completing the mechanical part, lots of work has been done such as drilling, welding metals and rivet.

3.1.4 Circuit Design

After the hardware development and the body of the machine is completed, the circuit is then designed to fulfill the project's requirements. In designing the circuit, all safety precautions are taken. Wiring process took place after circuit designing complete. Any error occurs; the process will go through the troubleshooting process and if it could not solved, the process will goes back to the literature review to search for the answer.

3.1.5 Software Development

Once all the hardware development and circuit design is completed, then the process continues with the software development. Here, the programming was constructed for automatic mode. The programming is using the FPWIN which is the software for the NAIS PLC.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This automatic book binding machine consists of mechanical part and electrical part. Thus, workloads are compiled. All parts of the body for this automatic book binding machine are metal-based. The metals are used in the process to construct the body of this machine; such as angle iron, ½ inch iron, rode iron, and iron block. Angle iron is used for the stand and more can be seen on the body of the machine. While ½ inch irons, round iron and the block are for the base of the book to move from one stage to another stage.

The automatic book binding machine is in an appropriate size which is suitable for users to use it. At the bottom of the machine there are six wheels attached to make it easier to move from one place to another.

The construction of the figure of the body makes it user friendly. This is because the tank of the hydraulic is too heavy. If we do not attach the wheels, it would make it difficult to move the machine. The book-placed based is designed for A4 paper size. The punching and binding processes are taken by hydraulic cylinder where the eye of punch is placed at the rod cylinder to make the hole.

Figure 4.1: Automatic Book Binding Machine

Many steps are taken to build the machine as constructed above (**refer to figure 4.1**), the works done by drilling, welding, riveting, and cutting the metal using
jigsaw. To join the iron to each other, the join is weld by using the welder. All safety precautions are taking to avoid any accidents.

The automatic book binding machine could not achieve 100% objective. It can only bind books about 4mm thickness because the hardware of this project is not strong enough.

4.1.1 Book Basement

This book-place basement is designed to place the book for the punching and binding process. This book basement is in the margin of A4 size, so that only A4 size paper can be used. It has two holes because the machine using the concept of 'puncher' to bind the book. The book-place basement is placed on the rail to make it easy to move from left to right, and the rail is going through the iron block. The book basement is made from angel iron and ½ inch iron and the rail is from the rode iron.

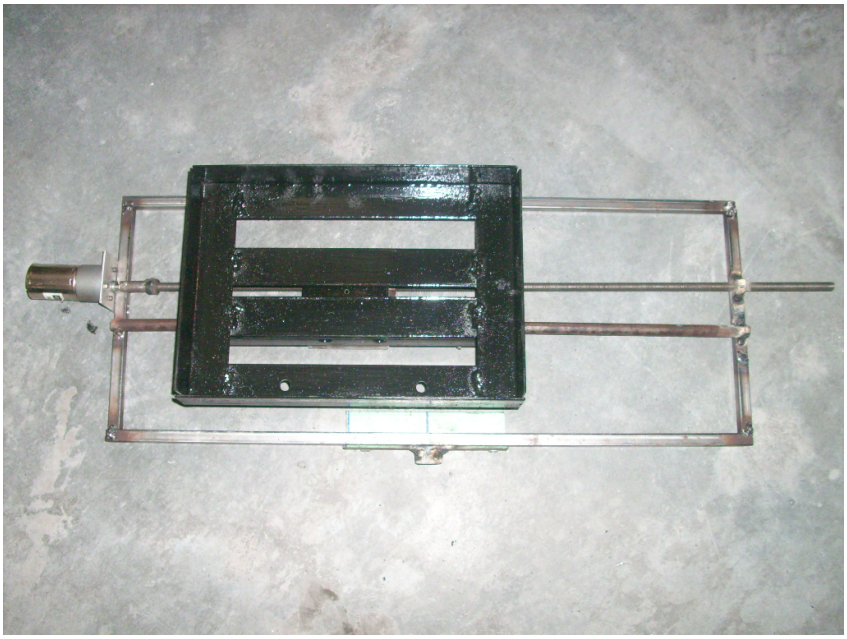

Figure 4.1.1: Book Basement

4.1.2 Hydraulic Tank Base

The Hydraulic tank basement is made from the angle iron because it is more stable to hold the tank as it is too heavy. This is because the tank is filled with the hydraulic fluid. Moreover, on top of the tank there are valve, induction motor and hydraulic pump. These components make the hydraulic tank becomes heavier.

Figure 4.1.2: Hydraulic tank basement

4.1.3 Hydraulic Cylinder Stand

The hydraulic cylinder stand is constructed to place the whole body of the machine onto it. It is made from angle iron as angel iron is stronger and able to hold the pressure produced by the cylinder.

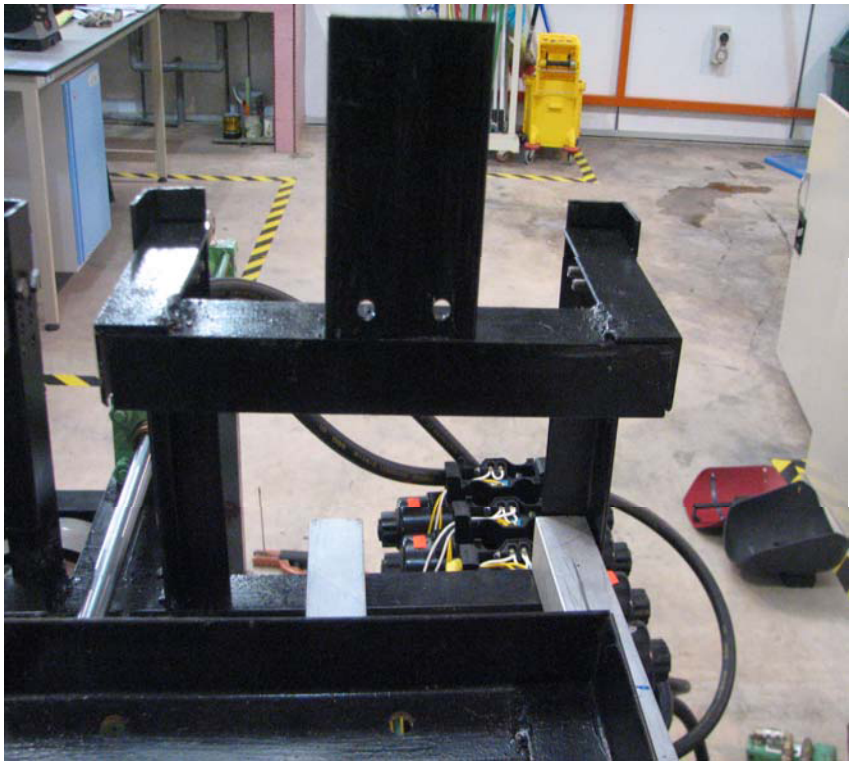

Figure 4.1.3: Hydraulic cylinder stand

4.2 System Design

This automatic book binding machine uses the hydraulic system for its operation. PLC is used to ensure operation of the system runs in automatic condition, where the PLC acts as the controller. Eventually, this machine may be operated manually and automatically. The manual system is turned on as back-up system once the automatic system fails to run. This will help users to continue using the machine without interference. This manual system is used to assemble or setting the operation before switching to automatic system. It uses direct wiring and all operations and movement are controlled by switches. This machine is equipped with an emergency stop button, in case of any interference or problems occurred in the middle of operation. The design of this machine has considered all the safety needs.

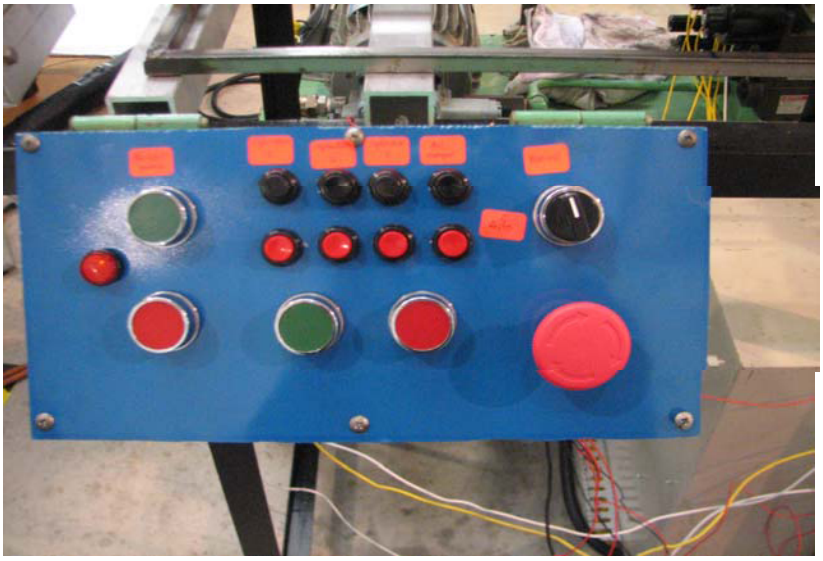

Figure 4.2: Switch Panel

4.3 Hydraulic System

Focusing on the hydraulic system, it consists of elements of control such as tank, induction motor, pump, filter, pressure gauge, oil-air cooler, valve, and cylinder. Hydraulic system functions to move the cylinder during the punching and binding process. Entire elements in this system are very important as it resembles the movement of the cylinder as well as safety needs of the system.

4.3.1 Hydraulic Pumps

A hydraulic pump is one of the elements in hydraulic system. This hydraulic pump functions to convert mechanical energy to hydraulic energy. The operation of this pump based on the displacement concept, where the fluid is transferred from the suction port of the pump to the pressure port. These pumps operate at a high system pressure because there is no direct connection between these two ports.

There are many types of hydraulic pumps such as gear pump, worm gear pump, vane pump, radial piston pump, and axial pump. All these pumps are set according to their displacement type. There are three types of displacement; gear, vane, and piston. All these types have their own model. Gear pump has three models; external gear pump, internal gear pump, and gear ring pump. Worm gear pump model is called screw pump. Vane pump has two models which is single chamber and double chamber. Radial piston pump has two types of models. There are eccentric cylinder block and eccentric shaft and for the axial piston pump, the models are bent axis and swashplate.

The pump that is being used in this project is variable vane pump. The type of model used is the single chamber type. This type of pump is operating where the movement of the stroke of the vanes is limited by a ring with a circular internal form.

Due to the off-centre position of the ring respect to the rotor, the volume is changed with the displacement chamber. [2] The maximum pressure of this pump is 35kg/cm2 and the speed is 1800rpm.

Figure 4.3.1: Vane variable pump

4.3.2 Induction motor

This project used the three phase induction motor with 3hp. The connection for this motor is delta connection (high voltage) which interprets the input for this motor of 415V. If the motor switch the connection to star connection and that the input is 240V, the starting current will rise up to 56.7A. This will trigger the control circuit to trip because of overload current. Starting current with the input of 415V, is only 2.2A. This shows that the motor used for the project must apply the delta connection. Compared to the theory, delta-connection is equal to three times star-connection, as followed:

$$Z_{\Delta} = 3Z_{Y} \qquad (3.1)$$

From the equation above, it is stated that the current will go high if the star-connection is used. The function of this motor is to activate the pump to pump the oil from tank to valve.

Figure 4.3.2: Induction motor

4.3.3 Hydraulic Cylinder

Hydraulic cylinder can be divided into two; single acting and double acting cylinder. It is the connector between hydraulic circuit and the working machine which it converts hydraulic energy to mechanical energy. This project used double acting cylinder where it enables the punching and binding process. The process begins when the cylinder extends. It has two ports to enable it to extend and retract. These two ports are connected to the valve by using the pipe, fitted to the port. Three double acting cylinders are being used. Two of them are short cylinders and the one left is a long cylinders. The long cylinder is used to move the book from one stage to another stage, while the short cylinder is used to enable the punching and binding process.

Figure 4.3.3: Double acting hydraulic cylinder

4.3.4 Hydraulic Valve

In the valve section, three types of valve are being used which are 4/3 way directional valve, twin throttle check valve and double check valve. The 4/3 way directional valve is used to control start, stop and the in-flow direction of the fluid. The function of the twin throttle check valve is to change the velocity of an actuator which is the main flow limitation and the double check valve functions to guarantee safe closing of both valves poppet. In controlling the speed of the hydraulic cylinder, the twin throttle valve has the adjustment element.

Figure 4.3.4: Hydraulic valve

4.3.5 Pressure Gauge

Pressure gauge is a pressure measuring device. There are two types of pressure gauges, they are pressure measuring device with bourdon tube and pressure measuring device with diaphragm. This project uses pressure measuring device with bourdon tube. This type is suitable to measure the pressure in fluid. It measures the velocity of the fluid into the valve which is about 400bar. This bourdon tube cannot be used in the medium with a high viscosity because it will easily damage.